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ASVAB Subtest and Composite Homogenization

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14. ABSTRACT
A study covering the past 20 years of Armed Services Vocational Aptitude Battery (ASVAB) data was conducted to determine if a trend exists between increasing intercorrelations of the subtests and composite scores and possible explanations for any findings. Analyses showed that overtime the Electronic Information (EI) and Paragraph Comprehension (PC) subtests have shown increased intercorrelations with the other subtests and an increasing extent to which the composites measure general mental ability (*g*). The report provides a few suggestions as to why the statistics demonstrate these findings and suggest the Air Force re-evaluate the benefits of attempting to add discriminant validity to the ASVAB.

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ASVAB, MAGE, General Cognitive Ability, *g*, Correlation, Validity

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EXECUTIVE SUMMARY

This study examined the Armed Services Vocational Aptitude Battery (ASVAB) over the past 20 years to determine if a trend existed toward increasing intercorrelations of the subtests and composites over time. In addition, the study suggested explanations for why this may have occurred and developed implications for future service use of classification composites. In the US Air Force, ASVAB subtests are assigned weights and combined to produce four composites used to qualify accessions for jobs categorized: Mechanical (M), Administrative (A), General (G), and Electronic (E) orMAGE. ASVAB subtest and MAGE composite data were examined in each year using factor analyses and by examining the correlations among subtests and among composites.

Subtest-level analysis showed that Paragraph Comprehension and Electronics Information had increasing correlations with several other subtests over time. In addition, the amount of general cognitive ability, *g*, being measured has increased in recent years. This could have occurred because of the change in test administration from paper-and-pencil to computer adaptive, a change in the content of the ASVAB (deletion of the 2 speeded subtests, Coding Speed and Numerical Operations and the addition of Assembling Objects), and/or a change in the structure of particular subtest items.

Examination of the changes in MAGE correlation matrices showed that the correlations are large and have dramatically increased. The largest increase involved the Mechanical and Administrative composites, and is a result of their modified composition in 1999. The intercorrelations of the composites now range from about .80 to about .90.

During the period included in this study, the ASVAB's higher component intercorrelations have resulted in a reduction in the battery's capacity for providing discriminant validity. Increasingly, the ASVAB has provided more of a measure of general mental ability and less a measure of specialized abilities. We recommend that the Air Force reevaluate the relative benefits of attempting to add discriminant validity to the ASVAB, and using additional or revised measures to better differentiate between abilities and more effective job assignment.

PREFACE

This effort was performed under the Research and Analyses contract with support from the Strategic Research and Assessment Branch, HQ Air Force Personnel Center. The goals of the project were to examine the potential trend in the "homogenization" of the ASVAB subtests and to suggest potential explanations and implications for this issue. The authors thank Dr. Malcolm Ree, Dr. Mark Teachout, and Ms. Lindsey Smith for providing helpful comments.

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ASVAB SUBTEST AND COMPOSITE HOMOGENIZATION

I. INTRODUCTION

The Armed Services Vocational Aptitude Battery (ASVAB*)* has been used by all military services since 1976 for the selection and classification of enlistees into occupations. Four ASVAB subtests make up the Armed Forces Qualifying Test (AFQT) which is used for qualification into the US military. In addition to enlistment qualification, the ASVAB has been given to high school students for the purpose of career exploration and counseling as part of the Career Exploration Program. Each service combines the ASVAB subtests into composites based on their own needs. Currently, the Air Force uses four composites to qualify accessions for jobs categorized as: Mechanical (M), Administrative (A), General (G), and Electronic (E) or MAGE. The MAGE composites are computed by adding weighted standard scores of the ASVAB subtests (Segall, 2004).

Any test with a long history is subject to planned or unplanned changes that evolve over time. There can be changes in the subject content of the subtests, timing and administration, mode of testing, reference population, and any number of similar sources. Most testing programs guard against any instability in the meaning and interpretation of test scores arising from such differences by carefully documenting the process of test and item revision. This would ensure, for example, that items written during periodic revisions conform to detailed specifications for item writing style, content domain, and psychometric integrity – the goal being that test items used as replacements parallel the items that are being replaced. Further, test score metrics are maintained by a well-established psychometric process known as equating.

In the mid 1980s, scores on the Numerical Operations (NO) and Coding Speed (CS) subtests were found to be much higher in a high school sample than in the reference population, indicating that test administration was not standardized across locations (Horne, 1986). In addition, it was found that the subtests were very sensitive to the type of hardware or answer sheets used during administration (Pommerich, Segall, & Moreno, 2009). These two subtests were dropped from all versions of the ASVAB and in 2002 another subtest, Assembling Objects (AO), was added. The AO subtest was developed as part of the U.S. Army's Project A, aimed at research and development to identify skills and abilities that were not currently measured by the ASVAB (Busciglio, Palmer, King, & Walker, 1994). AO was created as a measure of spatial visualization/mental rotation and was found to add incremental validity to the ASVAB.

II. THE CAT - ASVAB

In addition to the change in ASVAB content, the test has undergone a change from paper-and-pencil administration to primarily computer-adaptive testing (CAT). The ASVAB had many of the same problems associated with any paper-and-pencil test, such as the potential for item compromise and coaching by recruiters (Maier, 1993). In 1999, after many years of research, the Department of Defense (DoD) launched a computer adaptive version of the ASVAB (CAT-ASVAB). Instead of every examinee being given identical items, administered items are selected from a large pool of items of varying difficulty levels. By making the ASVAB a computer adaptive test, the content was less likely to be compromised because examinees would not necessarily receive the same items (Segall & Moreno, 1999). In addition, test time was reduced by almost half from paper-and-pencil to computer adaptive because examinees could be given fewer items to determine their ability level. It should be noted that paper-and-pencil versions of the ASVAB are still given at low volume Military Entrance Test (MET) sites where computers are not available and to students as part of the Career Exploration Program since it is not possible to have standardized computer testing stations available at each high school (Segall & Moreno, 1999).

Positive Manifold

More than a century ago, Spearman noted what he called positive manifold while doing research on cognitive ability tests. When an individual is given different cognitive ability tests, the resulting scores will correlate positively with each other, even when the tests purport to measure different abilities (e.g., a verbal test vs. a quantitative test). Spearman (1904) referred to this result of positive manifold in cognitive ability tests as *g*. This phenomenon has been noted in a multitude of ability tests (Jensen, 1998; Ree & Earles, 1991; Thurstone & Thurstone, 1941; Vernon, 1969). In cognitive testing with the military, psychometric *g* has been identified in several analyses of the ASVAB. In a confirmatory factor analysis, Ree and Carretta (1995) found that *g* accounted for 64% of the variance in the ASVAB. In addition, Frey and Detterman (2004) performed a principal-axis factor analysis on the ASVAB subtests in which all subtests substantially loaded on the first factor, *g*.

There has been some speculation by Air Force research sponsors that changes in the ASVAB over time may be affecting the way service-unique classification composites are used and interpreted. Currently, the CAT-ASVAB supports all military services in selection and classification by the use of separate composites specific to the needs of each service. If positive manifold were increasing among ASVAB subtests, then the composites would be less able to differentiate among individuals and classify them into meaningful job categories.

The purpose of this study was to take a retrospective look at the ASVAB over the past twenty years to examine if there has been a trend toward increasing positive manifold of the ASVAB subtests over time, as might be evident in the correlations among subtests and composites. An additional purpose was to explain why this may have occurred and to develop implications for future service use of classification composites.

III. METHOD

Subjects

The subjects included in this study were 754,354 U.S. Air Force applicants or high school students. Based upon reported gender information, there were 67% males and 25% females.

Instrument

All subjects took a form of the ASVAB consisting of nine or ten subtests depending on the year tested. Since the ASVAB became operational, various subtests have been removed and others added. From 1980 to 2002, the ASVAB consisted of eight power subtests, Word Knowledge (WK), Arithmetic Reasoning (AR), Mechanical Comprehension (MC), Auto and Shop Information (AS), Electronics Information (EI), Mathematics Knowledge (MK), General Science (GS), and Paragraph Comprehension (PC); and two speeded subtests, Numerical Operations (NO) and Coding Speed (CS). A speeded test is concerned with the number of questions an individual can answer correctly within an allotted time. A power test has items of varying difficulty that the individual should be able to complete within the allotted time.

With the change in test administration from a paper-and-pencil to a computer adaptive test, the content changed as well. The two speeded subtests present in the paper-and-pencil version (NO & CS) proved to be problematic when administered by computer and were removed. In their place, a spatial subtest, Assembling Objects (AO), was added that could be administered via computer. Descriptions of the subtests are included in Table 1. It should be noted that in the paper-and-pencil ASVAB, the subtests Auto Information (AI) and Shop Information (SI) are combined into a single subtest, Auto/Shop (AS). In the CAT-ASVAB, the AI and SI subtests are administered separately and then combined into a single score (AS).

Table 1. ASVAB Subtest Names and Descriptions

Subtest	Description	Paper-and-Pencil	CAT-ASVAB
General Science (GS)	Tests knowledge of the biological and physical sciences	X	X
Arithmetic Reasoning (AR)	Tests the ability to solve word problems using arithmetic	X	X
Word Knowledge (WK)	Measures the ability to select the correct meaning of in-context words and identify the synonym for a given word	X	X
Paragraph Comprehension (PC)	Tests the ability to gain information from written paragraphs	X	X
Math Knowledge (MK)	Tests the knowledge of high school level mathematics concepts	X	X

Electronics Information (EI)	Tests the knowledge of electronics and electricity	X	X
Auto and Shop Information (AS)	Tests the knowledge of automobile technology, shop, and tool terminology and concepts	X	X
Mechanical Comprehension (MC)	Tests the knowledge of physical and mechanical concepts and devices	X	X
Assembling Objects (AO)	Tests the ability to determine how an object will appear when its pieces are put together		X
Numerical Operations (NO)	Measures the ability perform arithmetic computations quickly	X	
Coding Speed (CS)	Measures the ability to process information from one list to another	X	

Note: In the paper-and-pencil ASVAB, the subtests Auto and Shop Information are combined into a single subtest, Auto/Shop (AS). In the CAT-ASV*AB*, the Auto and Shop subtests are administered separately and then combined into a single score (AS).

Procedure

The sample of ASVAB examinees were separated into two groups based on their date of testing so that within each group, the test content remained constant. One group was tested between 1989 and 1992 and the other between 2002 and 2008. The range of years chosen for analysis was based on the completeness of the data, comparative sample sizes, and consistency in type of test administered. For example, between 1993 and 2001, the paper-and-pencil ASVAB was being phased out of use in testing centers and the CAT-ASVAB was being phased in. Not everyone had access to testing centers with computers during that time so method of test administration was not standardized.

The first analysis compared the mean and standard deviation of subtest scores from each year included in the study. For the two groups, exploratory factor analyses were performed on the subtest scores as they were given each year. The percent of variance accounted for in the first factor was compared. The same was done for the eight subtests that remained common to the ASVAB over time. In addition, a difference matrix of the correlations from 1989 and 2008 was constructed to show the pairs of subtests with the largest increases. The same was done for the MAGE composite correlations. From this, the paired correlations among selected subtests were plotted over time on a line graph. A second line graph was constructed to show the change in MAGE composite correlations over time.

IV. RESULTS

Table 2 shows the means and standard deviations for the scores on the ten ASVAB subtests for applicants between 1989 and 1992. Table 3 shows the means and standard deviations for the scores on the nine subtests for applicants between 2002 and 2008. The earlier year scores and later year scores were measured on a different scale. Eight subtests are common to both groups. In the later years, NO and CS were removed and replaced with AO. Since some individuals tested between 2002 and 2008 took the paper-and-pencil version at a MET site or through the Career Exploration Program, they did not have a score on the AO subtest because it is only administered via computer. These individuals were not removed when means and standard deviations were calculated; therefore, sample sizes will be slightly different for AO versus the other subtests.

Table 2. **Means and Standard Deviations for ASVAB Subtests (1989 – 1992 Applicants)**

	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI
1989 (N = 82,123)										
Mean	16.98	19.90	27.90	12.54	41.89	54.90	14.44	15.88	16.05	11.97
SD	4.07	5.67	4.92	2.13	7.39	11.99	5.33	5.06	4.32	3.58
1990 (N = 64,204)										
Mean	17.31	20.45	28.40	12.68	42.16	55.42	14.60	16.41	16.31	12.11
SD	4.00	5.60	4.75	2.07	7.37	12.07	5.28	5.01	4.28	3.58
1991 (N = 84,639)										
Mean	17.48	20.64	28.71	12.67	41.93	55.79	15.19	16.26	16.52	12.42
SD	4.02	5.68	4.79	2.15	7.58	12.21	5.38	5.13	4.35	3.65
1992 (N = 78,068)										
Mean	17.44	20.30	28.41	12.58	39.48	54.31	14.64	16.41	16.27	12.20
SD	4.03	5.70	4.83	2.16	8.15	12.01	5.26	5.11	4.44	3.65

Table 3. **Means and Standard Deviations for ASVAB Subtests (2002 – 2008 Applicants)**

	GS	AR	WK	PC	AS	MK	MC	EI	AO
					2002				
N	77,661	77,661	77,661	77,661	77,661	77,661	77,661	77,661	76,805
Mean	52.02	52.28	52.67	53.46	48.54	54.91	51.70	50.61	53.06
SD	8.01	7.98	6.27	6.99	8.56	7.52	9.11	8.25	8.31
					2003				
N	71,215	71,215	71,215	71,215	71,215	71,215	71,215	71,215	66,050
Mean	52.51	52.79	52.94	53.99	48.53	55.72	51.90	51.00	53.63
SD	7.83	7.77	6.00	6.69	8.37	7.28	8.98	8.04	8.21
					2004				
N	59,054	59,054	59,054	59,054	59,054	59,054	59,054	59,054	52,719
Mean	52.34	52.78	52.17	53.71	49.01	55.24	52.39	51.51	54.39
SD	7.95	7.70	6.74	6.74	8.81	7.24	8.87	8.46	8.18

					2005				
N	55,230	55,230	55,230	55,230	55,230	55,230	55,230	55,230	49,532
Mean	52.19	52.75	51.25	53.24	50.04	54.32	53.36	52.34	55.60
SD	8.07	7.64	7.55	6.70	9.34	7.09	8.62	9.08	7.91
					2006				
N	58,338	58,338	58,338	58,338	58,338	58,338	58,338	58,338	52,893
Mean	52.04	52.62	51.05	53.14	49.83	54.21	53.30	52.12	55.54
SD	8.14	7.67	7.63	6.69	9.38	7.03	8.60	9.11	7.93
					2007				
N	57,797	57,797	57,797	57,797	57,797	57,797	57,797	57,797	52,791
Mean	51.87	52.54	50.92	53.10	49.47	54.10	53.16	51.85	55.52
SD	8.22	7.68	7.65	6.75	9.24	6.98	8.58	9.09	8.03
					2008				
N	66,025	66,025	66,025	66,025	66,025	66,025	66,025	66,025	61,230
Mean	51.88	52.68	50.99	53.16	49.24	54.22	53.19	51.91	55.41
SD	8.21	7.79	7.65	6.74	9.26	7.02	8.59	9.16	7.99

Table 4 shows the means and standard deviations for the percentile scores on the ASVAB MAGE composites (Mechanical, Administrative, General, and Electronics) for applicants between 1989 and 1992. Table 5 shows the means and standard deviations for the percentile scores on the MAGE composites for applicants between 2002 and 2008.

Table 4. Means and Standard Deviations for ASVAB Composites (1989 – 1992 Applicants)

	M	A	G	E
1989 (N = 82,123)				
Mean	55.03	62.18	56.72	56.76
SD	24.59	21.65	21.35	21.51
1990 (N = 64,204)				
Mean	56.49	63.83	59.13	58.97
SD	24.23	21.53	21.09	21.14
1991 (N = 84,639)				
Mean	58.67	64.67	60.13	59.91
SD	24.46	21.97	21.57	21.47
1992 (N = 78,068)				
Mean	56.39	63.93	58.72	59.15
SD	24.54	22.04	21.66	21.51

Table 5. Means and Standard Deviations for ASVAB Composites (2002 – 2008 Applicants)

	M	A	G	E
		2002 (N = 77,661)		
Mean	54.06	62.82	57.81	58.74
SD	23.45	20.45	23.35	21.57
		2003 (N = 71,215)		
Mean	55.03	64.89	59.26	60.61
SD	22.77	19.65	21.66	20.83
		2004 (N = 59,054)		
Mean	55.28	63.36	58.66	60.61
SD	23.54	20.51	22.34	21.97
		2005 (N = 55,230)		
Mean	56.51	61.07	58.20	60.69
SD	24.69	21.22	23.23	23.66
		2006 (N = 58,338)		
Mean	56.05	60.65	57.79	60.21
SD	24.89	21.23	23.43	23.93
		2007 (N = 57,797)		
Mean	55.48	60.26	57.46	59.62
SD	24.90	21.27	23.50	24.02
		2008 (N = 66,025)		
Mean	55.54	60.59	57.84	59.89
SD	25.05	21.36	23.68	24.18

Factor Analyses

To examine the factor structure present in the early group of applicants, a principal components factor analysis with varimax rotation extracting four factors was performed on the subtest scores from applicants between 1989 and 1992. Factor loadings above .4 were considered practically significant (Floyd & Widaman, 1995); therefore, in Table 8 only loadings of .4 or greater are in bold. The four factors were identified as Technical, Verbal, Math, and Speed. Subtest loadings on each factor are shown in Table 6. Auto Shop, Mechanical Comprehension, and Electronics Information had significant loadings on the Technical factor. Word Knowledge and Paragraph Comprehension had significant loadings on the Verbal factor. Arithmetic Reasoning and Math Knowledge had significant loadings on the Math factor with Mechanical Comprehension having some loading on this factor as well. Numerical Operations and Coding Speed loaded significantly on the Speed factor since they both require speed at completing simple tasks with a high degree of accuracy. General Science had partial loading on both the Technical and Verbal factor, with a slightly larger loading on the Verbal factor.

Table 6. Exploratory Factor Analysis of ASVAB Subtests (1989 – 1992 Applicants)

	Technical	Verbal	Math	Speed
GS	**0.50**	**0.57**	0.37	-0.03
AR	0.33	0.28	**0.74**	0.22
WK	0.27	**0.82**	0.23	0.08
PC	0.11	**0.85**	0.16	0.18
NO	-0.04	0.05	0.28	**0.83**
CS	-0.02	0.14	0.04	**0.90**
AS	**0.90**	0.10	0.02	-0.05
MK	0.10	0.23	**0.87**	0.21
MC	**0.72**	0.20	**0.40**	0.01
EI	**0.83**	0.23	0.14	-0.01

N = (309,034). Note: Factor loadings ≥ .40 are shown in bold.

Figure 1 shows a visual representation of the subtests and their loadings on each factor for the years 1989 through 1992. The amount of variance accounted for in the first factor was 44.06%.

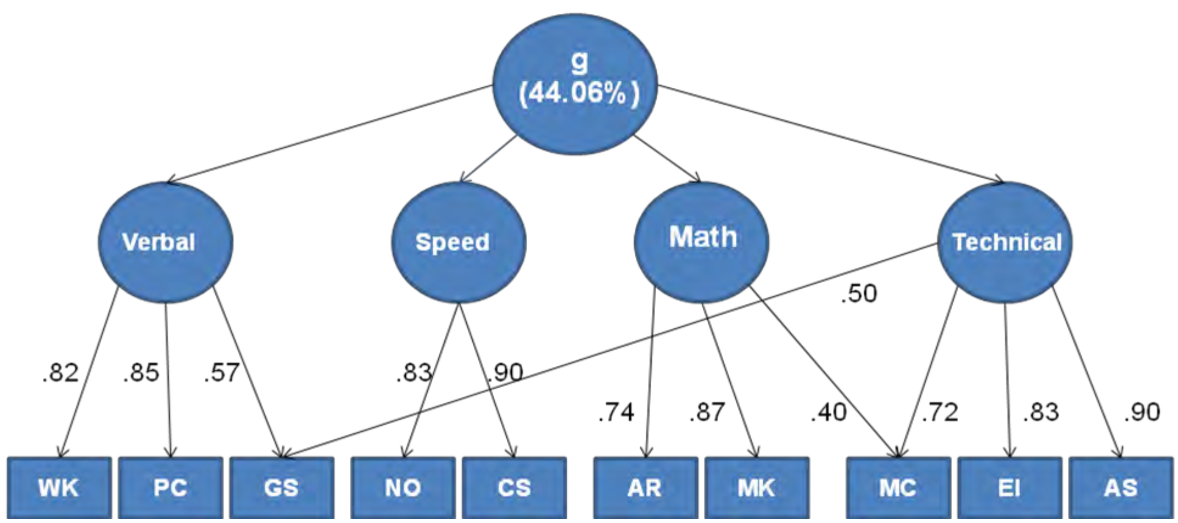

Figure 1. Exploratory Factor Analysis of the ASVAB Subtests (1989 – 1992)

To examine the factor structure present in the later group of applicants, a principal components factor analysis with varimax rotation extracting four factors was performed on the subtest scores from 2002 to 2008. Only loadings of .4 or greater are in bold. The four factors were identified as Technical, Verbal, Math, and Spatial. Subtest loadings on each factor are shown in Table 7. The results were generally consistent with those from the 1989-1992 paper-and-pencil test. AS, GS, MC, and EI had significant loadings on the Technical factor. GS, WK, and PC had significant loadings on the Verbal factor. AR and MK had significant loadings on the Math factor. AO loaded significantly on the Spatial factor. In contrast to the 1989-1992 paper-and-pencil analyses, the loading for MC on Math was below the .40 threshold (MC factor loading on Math in the more recent data was .30, instead of .40).

Table 7. Exploratory Factor Analysis of the ASVAB Subtests (2002 – 2008)

	Technical	Verbal	Math	Spatial
GS	**0.49**	**0.65**	0.30	0.10
AR	0.32	0.32	**0.75**	0.23
WK	0.29	**0.84**	0.19	0.06
PC	0.13	**0.82**	0.25	0.20
AS	**0.91**	0.14	0.01	0.10
MK	0.06	0.24	**0.91**	0.15
MC	**0.70**	0.25	0.30	0.38
EI	**0.77**	0.35	0.21	0.09
AO	0.21	0.16	0.23	**0.92**

N = (412,020). Note: Factor loadings ≥ .40 are shown in bold.

Figure 2 shows a visual representation of the subtests and their loadings on each factor for the years 2002 through 2008. The amount of variance accounted for in the first factor was 55.04%.

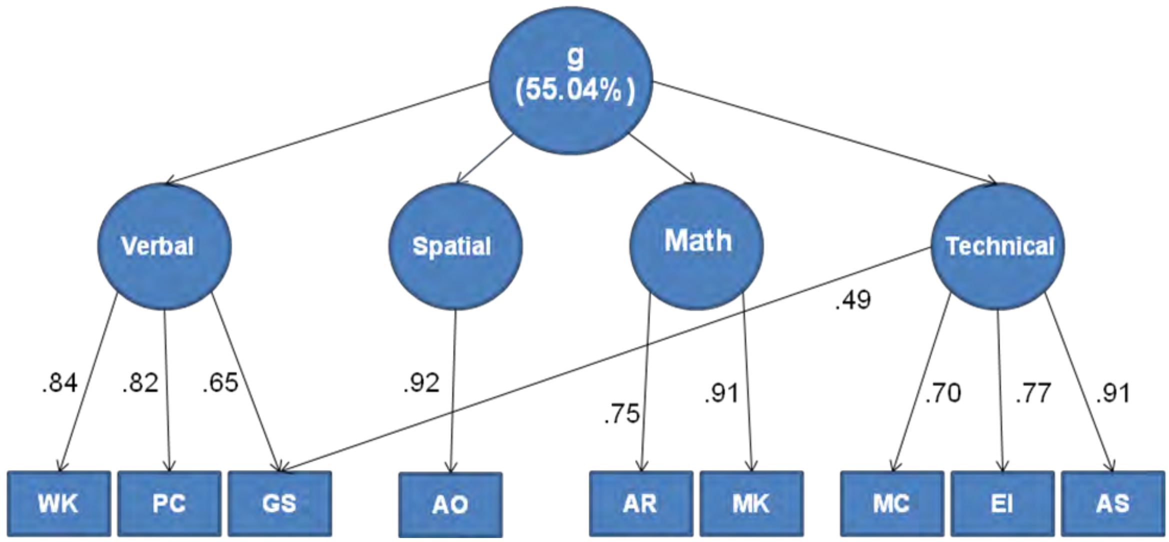

Figure 2. Exploratory Factor Analysis of the ASVAB Subtests (2002 – 2008)

Next, the percent of variance accounted for in the first unrotated factor (*g*) was examined to determine if the amount of general cognitive ability being measured has increased over time. Table 8 shows the percent of variance accounted for in the first unrotated factor from a principal components factor analysis. The subtests included were the ten given on the paper-and-pencil version in 1989 to 1992 and the nine given on the computer adaptive test in 2002 to 2008. To accentuate differences between paper-and-pencil and the computer adaptive versions, high school students who tested in 2002 through 2008 on a paper-and-pencil version were not included. Unfortunately, the extent to which psychometric changes between 1989-1992 and 2002-2008 reflect generational or educational differences rather than test format changes cannot be estimated by the data presented. The average first factor variance accounted for in the test from 1989 to 1992 was 44.06% and from 2002 to 2008 it was 55.44%.

Table 8. Percent of Variance Accounted for in the First Unrotated Factor from Test "As-Is"

Test Administration	Year	N	1st Factor	Average Variance
Paper-and-Pencil	1989	82123	43.74%	44.06%
	1990	64204	43.37%	
	1991	84639	44.44%	
	1992	78068	44.70%	
CAT-ASVAB	2002	76805	55.20%	55.44%
	2003	66050	54.31%	
	2004	52719	54.75%	

2005	49532	55.58%
2006	52893	55.63%
2007	52791	56.20%
2008	61230	56.44%

Table 9 shows the percent of variance accounted for in the first unrotated factor from a principal components factor analysis of the eight common subtests given on the paper-and-pencil version in 1989 to 1992 and the computer adaptive test in 2002 to 2008. Subtests that were not common across the years being examined were not included in the analysis. The average amount of variance accounted for by the first factor in the test from 1989 to 1992 was 53.48% and from 2002 to 2008 was 58.26%.

Table 9. Percent of Variance Accounted for in the First Unrotated Factor from 8 Common Subtests

Test Administration	Year	N	1st Factor	Average Variance
Paper-and-Pencil	1989	82123	53.36%	53.48%
	1990	64204	52.78%	
	1991	84639	53.62%	
	1992	78068	54.14%	
CAT-ASVAB	2002	76805	58.05%	58.26%
	2003	66050	57.07%	
	2004	52719	57.57%	
	2005	49532	58.37%	
	2006	52893	58.42%	
	2007	52791	59.06%	
	2008	61230	59.28%	

Correlations

To examine the trend in subtest correlations over time, a difference matrix is shown in Table 10. The correlations between pairs of the eight common subtests in 1989 were subtracted from those in 2008. Subtest correlations that increased by .100 or more are in bold and involved either the Electronics Information subtest or the Paragraph Comprehension subtest. The pair with the greatest increase over time was between EI and PC, a change of .178 from 1989 to 2008. Complete correlation matrices by year can be found in Appendix A.

Table 10. Change in ASVAB Subtest Correlations from 1989 to 2008

	GS	AR	WK	PC	AS	MK	MC	EI
GS	---							
AR	.045	---						
WK	.069	.024	---					
PC	**.117**	**.130**	.038	---				
AS	.029	.008	.081	**.113**	---			
MK	.000	.057	.001	.075	-.013	---		
MC	.062	.069	.097	**.150**	.040	.027	---	
EI	.090	**.100**	**.149**	**.178**	.006	.057	.075	---

1989 N = (82,123). 2008 N = (61,230). Correlation differences ≥ .100 are shown in bold.

Since EI had some of the greatest increases in correlations with other subtests over time, a line graph (Figure 3) was created to show the trend of these correlations. The graph does not contain data from the years of 1993 to 2001 since they were not included in our analyses. The key included in the graph groups each subtest being correlated with EI into its appropriate category: Technical, Verbal, or Math.

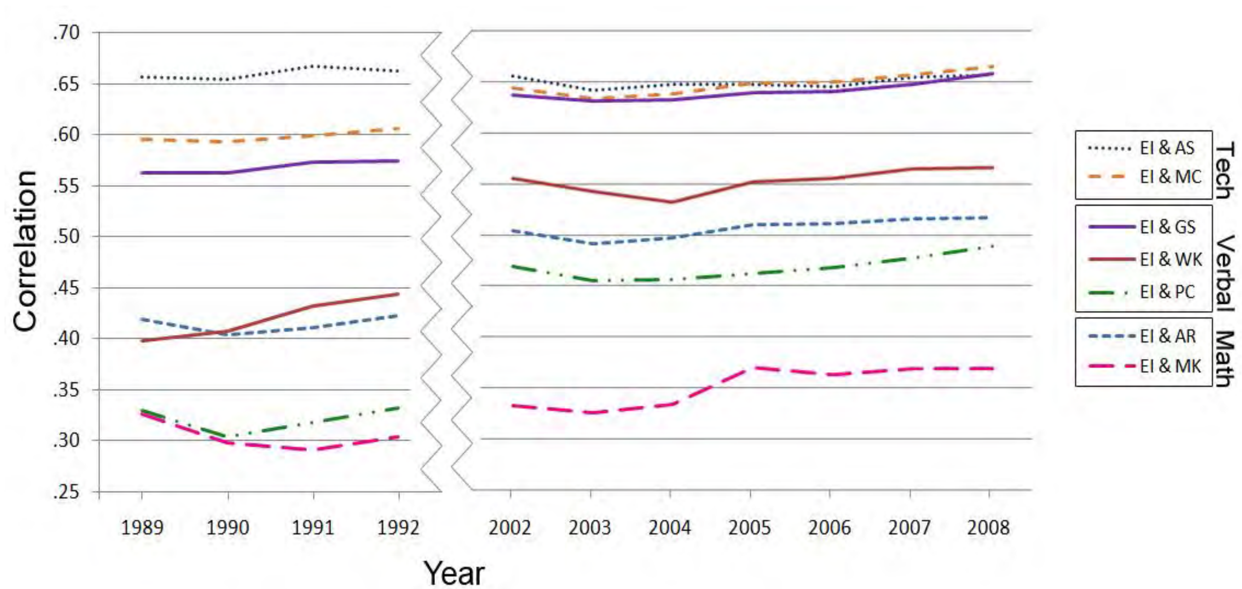

Figure 3. Correlations of EI with Other Common Subtests (1989 – 2008)

Since PC also had some of the greatest increases in correlations with other subtests over time, a line graph (Figure 4) was created to show the trend of these correlations. The graph does not contain data from the years of 1993 to 2001 since they were not included in our analyses. The key included in the graph groups each subtest being correlated with PC into its appropriate category: Technical, Verbal, or Math.

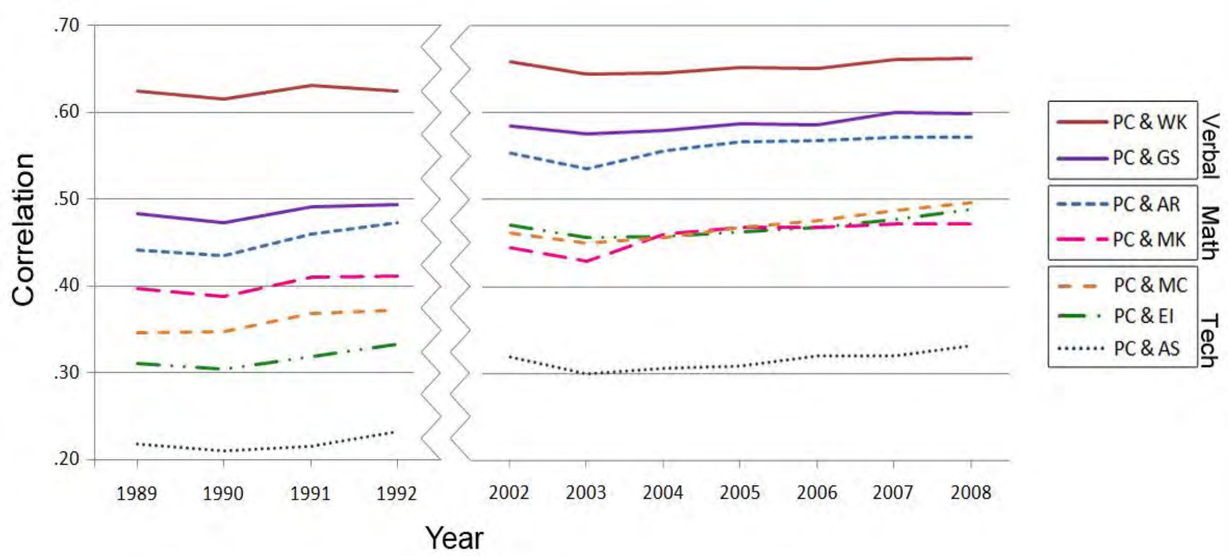

Figure 4. Correlations of PC with Other Common Subtests (1989 – 2008)

The same process was used to examine the trend in MAGE composite correlations over time. Note that the dramatic increases in correlations between MAGE composites over the time period studied possibly reflect formula changes in how even the eight common subtests are weighted in each MAGE composite (see Table 12) and not solely changes in the psychometric properties of the underlying subtests. A difference matrix is shown in Table 11. The correlations between pairs of the MAGE composites in 1989 were subtracted from those in 2008. Composite correlations that increased by .100 or more are in bold. All correlations except that between the General and Electronics composites had an increase greater than .100. The largest increase was between the Mechanical and Administrative composites with a very large change of .632 from 1989 to 2008. Of note, these composite-level comparisons may be of limited value due to the removal of MO and CS, which affect two of the four MAGE composites. Complete correlation matrices by year can be found in the Appendix.

Table 11. Change in MAGE Correlations from 1989 to 2008

	MECH	ADMIN	GEN	ELECT
MECH	---			
ADMIN	**.632**	---		
GEN	**.314**	**.323**	---	

ELECT	**.125**	**.412**	.029	---

Figure 5 shows all of the correlations between the Mechanical, Administrative, General, and Electrical composites. The graph does not contain data from the years of 1993 to 2001 since they were not available for our analyses. As is apparent in the graph, there is a substantial increase in correlations between composites.

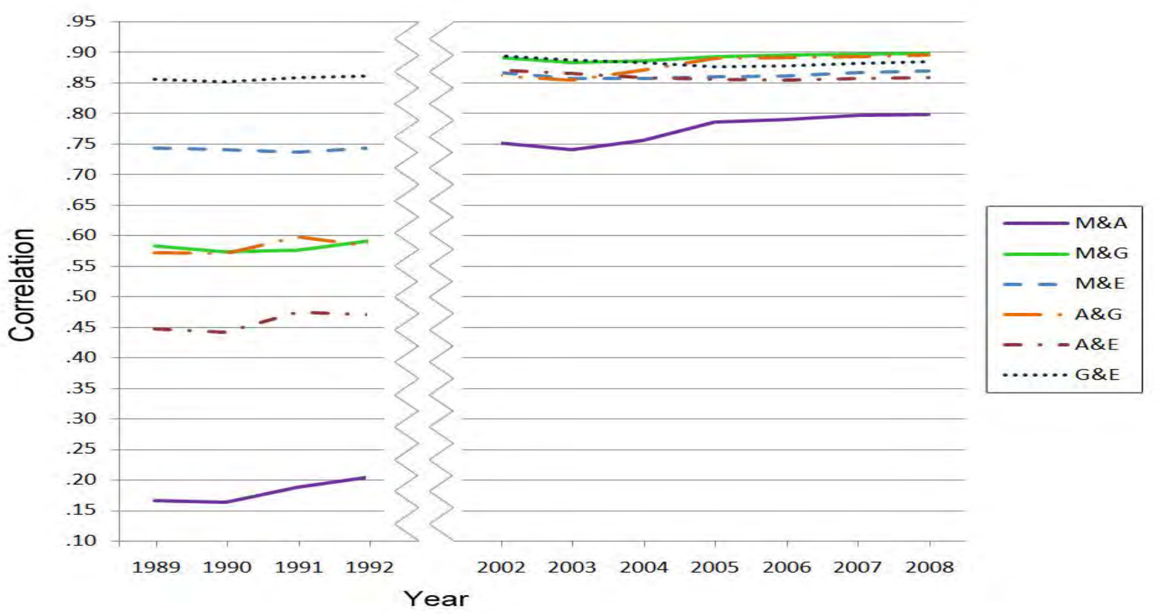

Figure 5. Correlation of MAGE Composites (1989 – 2008)

Table 12 shows the subtests comprising the MAGE composites. When the Air Force dropped the speeded subtests Numerical Operations and Coding Speed, the composites consisting of those two subtests were restructured. In 1999, the Mechanical and Administrative composites changed to incorporate Verbal Expression (VE, which combined WK and PC), while the General and Electrical composites stayed the same.

Table 12. Subtests Comprising the MAGE Composites

Composites	Old MAGE Composites	Current MAGE Composites
Mechanical	MC + GS + 2(AS)	AR + MC + AS + 2(VE)
Administrative	NO + CS + WK + PC	MK + VE
General	AR + VE	AR + VE
Electrical	GS + AR + MK + EI	GS + AR + MK + EI

Note: VE = (WK + PC) (Raw) Standardized

V. DISCUSSION

The purpose of this study was to examine the increased intercorrelations among the ASVAB subtests and composites over the past twenty years.

Factor Analyses

The present study identified a verbal attainment, quantitative attainment, technical knowledge, and speeded factor from a factor analysis of the 1989 to 1992 data. The subtests loaded on factors in a pattern similar to Bock and Moore's (1986) factor analysis. The exception was the GS subtest, which had a much higher loading on the verbal factor in the Bock and Moore analysis (.49 on verbal and only .27 on technical), yet loaded almost equally on the verbal and technical factors in the current study (.57 on verbal and .50 on technical). The GS subtest was noted by Bock and Moore to require both verbal ability and specialized knowledge of physical science and biology. In the factor analysis from the current study, GS appears to be more technical in content than it was in the Bock and Moore factor analysis. In addition, the loadings reported in the current study were consistently higher (with increases ranging from .02 to .37) than those found by Bock and Moore. The increase of .37 was found for the PC subtest on the verbal factor.

The exploratory factor analysis performed on the subtest scores from 2002 to 2008 yielded a pattern of loadings similar to the 1989-1992 analysis, with a few exceptions. First, AO on the spatial factor replaced NO and CS on the speed factor. Secondly, MC loaded significantly on only the technical factor whereas in 1989-1992, it loaded on both the technical and math factors. The analyses provide support that with the elimination and addition of various subtests, the factor structure remained relatively stable over time, given that AO warranted its own spatial factor in place of the excluded speeded component.

The amount of variance accounted for by the first unrotated factor from both the 1989-1992 and 2002-2008 data showed that the amount of psychometric g in the ASVAB changed markedly from the earlier to later ASVAB versions. In the first set of analyses, the full complement of ASVAB subtests was used, ten subtests including NO and CS for 1989-1992 and nine subtests excluding NO and CS but adding AO for 2002-2008. When comparing the general factor (g) as it was affected by both the change in subtests and method of administration, it showed an increase from 44% in the paper-and-pencil version to 55% in the CAT version. When only the eight common subtests were analyzed, the g component increased from 53% in the paper-and-pencil version to 58% in the computer administered version.

One possibility that cannot be ruled out by this research project is that the amount of psychometric g measured in the ASVAB increased from 1989-1992 to 2002-2008 because of a decrease in unsystematic error that had been due to improper test administration issues in the use of paper-and-pencil tests by high schools (as noted in Pommerich, Segall, & Moreno, 2009). If test-retest reliability of subtests was higher in 2002-2008 than in 1989-1992 this would support the idea that greater measured psychometric *g* among common subtests in the current ASVAB format is simply an artifact of more reliable measurement of each subtest.

Correlations

It is evident from the correlation matrices that while some relationships among the subtests remain constant over time, there is a general trend towards higher correlations among specific subtests. Particularly, the subtests EI and PC had the largest increase in correlations with other subtests. It is likely that the change in the item specifications and test administration contributed to this increase; however generational or educational changes in test-takers over time may have alternately accounted for the increased correlation between subtests. As an example of changes in item specifications, when the ASVAB was created as a computer adaptive test, the subtest lengths were shortened by 40 to 50 percent, and for the PC subtest this meant asking one question on each passage (Segall & Moreno, 1999). In addition, since EI is a technical subtest and PC is a verbal subtest, it is likely that EI is more correlated with PC because EI has become less technical in nature. For example, the questions on the EI subtest might now require more verbal skills to complete. Thus, the changing nature of subtests over time could be a contributing factor to the increasing correlations.

The largest factor affecting the intercorrelations of the MAGE composites was the change in the calculation of the Mechanical (M) and Administrative (A) composites in 1999. The General (G) and Electronic (E) were not changed, but their intercorrelations have always been high, from about .85 during 1989-1992 to about .90 during 2002-2008. The other composite intercorrelations increased substantially after 1999 so that now they are all between .80 and .90. The greatest part of this increase is clearly due to the change in the content of the M and A composites, but a small contribution is likely due to the increase in subtest correlations.

V. IMPLICATIONS

Greater commonality of subtests and composites results in less differentiation in assigning people into Air Force Specialties. It would likely be useful to further explore the tradeoffs in the relative merits of greater validity of composites versus greater discriminant validity. The problems associated with the increasing homogenization of the subtests in the ASVAB could be addressed on more fundamental levels. The subtest content should be examined to determine if the items on certain subtests have become too general in nature, rather than measuring specific knowledge found in the paper-and-pencil test taxonomy and item specifications. Specifically, the items on the Paragraph Comprehension subtest could be examined from paper-and-pencil and computer adaptive forms. A visual inspection could determine if the items had changed, leading to inadvertent consequences. The CAT philosophy could be reviewed in terms of the basic item-selection algorithms and item formats that have been imposed by that method of administration. For example, are there any implicit item selection rules that could lead to less homogenized content? To further investigate the positive manifold found among MAGE composites, their correlations prior to being restructured in 1999 should be compared to the current MAGE composites. Additional comparisons could be made with the ten alternative composites to determine their relative suitability.

The extent to which increased correlation among ASVAB subtests reflect generational or educational background changes in test-takers, rather than test content or administration changes, could be assessed by conducting a separate analysis of the particular test centers in which paper-and-pencil tests were administered to all test-takers during both the 1989-1992 and (at least some portion of) the 2002-2008 time period.

The Air Force should always be vigilant for new measures that will enhance current measures. A survey to identify useful measures predictive of enlisted job success might contribute to developing new tests that would offer increased discriminant validity for assignment to Air Force training specialties.

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APPENDIX A
ASVAB SUBTEST AND COMPOSITE CORRELATION MATRICES

Table A1. **Correlation Matrix for ASVAB Subtests in 1989**

	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI
GS	1									
AR	.531	1								
WK	.646	.508	1							
PC	.482	.441	.624	1						
NO	.118	.340	.187	.230	1					
CS	.060	.238	.164	.223	.571	1				
AS	.490	.371	.328	.218	-.057	-.095	1			
MK	.482	.655	.432	.396	.378	.268	.176	1		
MC	.571	.540	.432	.346	.064	.026	.607	.418	1	
EI	.568	.417	.418	.311	.018	-.023	.651	.312	.590	1

N = 82,123

Table A2. **Correlation Matrix for ASVAB Subtests in 1990**

	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI
GS	1									
AR	.521	1								
WK	.638	.494	1							
PC	.473	.434	.615	1						
NO	.117	.351	.186	.224	1					
CS	.067	.251	.170	.227	.570	1				
AS	.481	.357	.318	.210	-.053	-.087	1			
MK	.475	.658	.421	.387	.385	.276	.161	1		
MC	.568	.536	.427	.348	.074	.040	.600	.425	1	
EI	.563	.404	.407	.304	.012	-.021	.654	.299	.593	1

N = 64,204

Table A3. **Correlation Matrix for ASVAB Subtests in 1991**

	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI
GS	1									
AR	.531	1								
WK	.649	.512	1							
PC	.490	.459	.631	1						
NO	.143	.377	.199	.264	1					
CS	.103	.287	.202	.267	.584	1				
AS	.478	.349	.338	.216	-.064	-.070	1			
MK	.482	.667	.421	.410	.420	.310	.139	1		
MC	.581	.545	.449	.369	.100	.075	.600	.425	1	
EI	.573	.411	.432	.319	.011	-.001	.668	.291	.599	1

N = 84,639

Table A4. Correlation Matrix for ASVAB Subtests in 1992

	GS	AR	WK	PC	NO	CS	AS	MK	MC	EI
GS	1									
AR	.538	1								
WK	.651	.522	1							
PC	.493	.472	.624	1						
NO	.126	.350	.181	.239	1					
CS	.096	.276	.189	.256	.608	1				
AS	.482	.360	.351	.232	-.043	-.052	1			
MK	.483	.666	.428	.411	.380	.295	.153	1		
MC	.579	.554	.452	.372	.089	.077	.603	.431	1	
EI	.574	.423	.444	.333	.029	.015	.663	.304	.606	1

N = 78,068

Table A5. Correlation Matrix for ASVAB Subtests in 2002

	GS	AR	WK	PC	AS	MK	MC	EI	AO
GS	1								
AR	.574	1							
WK	.717	.526	1						
PC	.583	.551	.657	1					
AS	.515	.387	.421	.317	1				
MK	.460	.681	.394	.443	.128	1			
MC	.618	.601	.512	.460	.649	.412	1		
EI	.637	.504	.555	.469	.655	.334	.644	1	
AO	.392	.495	.330	.361	.295	.429	.530	.368	1

N = 76,805

Table A6. Correlation Matrix for ASVAB Subtests in 2003

	GS	AR	WK	PC	AS	MK	MC	EI	AO
GS	1								
AR	.554	1							
WK	.702	.501	1						
PC	.565	.520	.631	1					
AS	.488	.364	.391	.286	1				
MK	.454	.677	.382	.420	.116	1			
MC	.602	.580	.497	.438	.640	.402	1		
EI	.627	.483	.537	.445	.632	.326	.630	1	
AO	.393	.488	.317	.348	.294	.421	.534	.361	1

N = 66,050

<u>Table A7</u>. Correlation Matrix for ASVAB Subtests in 2004

	GS	AR	WK	PC	AS	MK	MC	EI	AO
GS	1								
AR	.561	1							
WK	.697	.509	1						
PC	.564	.531	.631	1					
AS	.484	.360	.379	.285	1				
MK	.472	.688	.419	.445	.122	1			
MC	.595	.573	.480	.435	.638	.397	1		
EI	.625	.485	.527	.441	.635	.332	.633	1	
AO	.389	.493	.309	.346	.310	.412	.540	.374	1

N = 52,719

<u>Table A8</u>. Correlation Matrix for ASVAB Subtests in 2005

	GS	AR	WK	PC	AS	MK	MC	EI	AO
GS	1								
AR	.559	1							
WK	.700	.515	1						
PC	.570	.542	.638	1					
AS	.483	.359	.383	.285	1				
MK	.477	.705	.417	.454	.146	1			
MC	.594	.575	.498	.447	.636	.421	1		
EI	.627	.494	.543	.445	.637	.360	.644	1	
AO	.399	.503	.331	.362	.304	.440	.537	.377	1

N = 55,230

<u>Table A9</u>. Correlation Matrix for ASVAB Subtests in 2006

	GS	AR	WK	PC	AS	MK	MC	EI	AO
GS	1								
AR	.560	1							
WK	.701	.515	1						
PC	.570	.547	.636	1					
AS	.493	.364	.394	.302	1				
MK	.472	.701	.410	.455	.147	1			
MC	.598	.584	.503	.459	.638	.423	1		
EI	.631	.497	.548	.453	.636	.356	.644	1	
AO	.392	.499	.335	.368	.311	.438	.539	.381	1

N = 52,893

Table A10. Correlation Matrix for ASVAB Subtests in 2007

	GS	AR	WK	PC	AS	MK	MC	EI	AO
GS	1								
AR	.579	1							
WK	.719	.537	1						
PC	.600	.571	.661	1					
AS	.511	.382	.408	.320	1				
MK	.480	.706	.430	.471	.165	1			
MC	.626	.606	.532	.488	.642	.444	1		
EI	.648	.515	.565	.477	.655	.369	.657	1	
AO	.396	.499	.343	.371	.308	.438	.541	.385	1

N=52,791

Table A11. Correlation Matrix for ASVAB Subtests in 2008

	GS	AR	WK	PC	AS	MK	MC	EI	AO
GS	1								
AR	.576	1							
WK	.716	.533	1						
PC	.599	.570	.662	1					
AS	.519	.379	.409	.331	1				
MK	.482	.712	.433	.471	.163	1			
MC	.633	.609	.528	.497	.646	.445	1		
EI	.658	.517	.566	.489	.657	.368	.665	1	
AO	.400	.506	.344	.376	.313	.436	.545	.390	1

N=61,230

Table A12. Correlation Matrix for ASVAB Composites in 1989

	MECH	ADMIN	GEN	ELECT
MECH	1			
ADMIN	.167	1		
GEN	.584	.573	1	
ELECT	.745	.447	.856	1

N=82,123

Table A13. Correlation Matrix for ASVAB Composites in 1990

	MECH	ADMIN	GEN	ELECT
MECH	1			
ADMIN	.163	1		
GEN	.574	.571	1	
ELECT	.742	.441	.852	1

N=64,110

Table A14. Correlation Matrix for ASVAB Composites in 1991

	MECH	ADMIN	GEN	ELECT
MECH	1			
ADMIN	.188	1		
GEN	.576	.598	1	
ELECT	.737	.474	.859	1

N=84,147

Table A15. Correlation Matrix for ASVAB Composites in 1992

	MECH	ADMIN	GEN	ELECT
MECH	1			
ADMIN	.204	1		
GEN	.592	.584	1	
ELECT	.744	.470	.862	1

N=77,500

Table A16. Correlation Matrix for ASVAB Composites in 2002

	MECH	ADMIN	GEN	ELECT
MECH	1			
ADMIN	.752	1		
GEN	.892	.862	1	
ELECT	.867	.872	.894	1

N=77,661

Table A17. Correlation Matrix for ASVAB Composites in 2003

	MECH	ADMIN	GEN	ELECT
MECH	1			
ADMIN	.742	1		
GEN	.883	.856	1	
ELECT	.857	.865	.887	1

N=71,215

Table A18. Correlation Matrix for ASVAB Composites in 2004

	MECH	ADMIN	GEN	ELECT
MECH	1			
ADMIN	.757	1		
GEN	.886	.871	1	
ELECT	.857	.859	.883	1

N=59,054

Table A19. Correlation Matrix for ASVAB Composites in 2005

	MECH	ADMIN	GEN	ELECT
MECH	1			
ADMIN	.787	1		
GEN	.893	.891	1	
ELECT	.860	.856	.877	1

N=55,230

Table A20. Correlation Matrix for ASVAB Composites in 2006

	MECH	ADMIN	GEN	ELECT
MECH	1			
ADMIN	.791	1		
GEN	.895	.892	1	
ELECT	.861	.856	.878	1

N=58,338

Table A21. Correlation Matrix for ASVAB Composites in 2007

	MECH	ADMIN	GEN	ELECT
MECH	1			
ADMIN	.798	1		
GEN	.897	.894	1	
ELECT	.867	.857	.881	1

N=57,797

Table A22. Correlation Matrix for ASVAB Composites in 2008

	MECH	ADMIN	GEN	ELECT
MECH	1			
ADMIN	.799	1		
GEN	.898	.896	1	
ELECT	.870	.859	.885	1

N=66,025